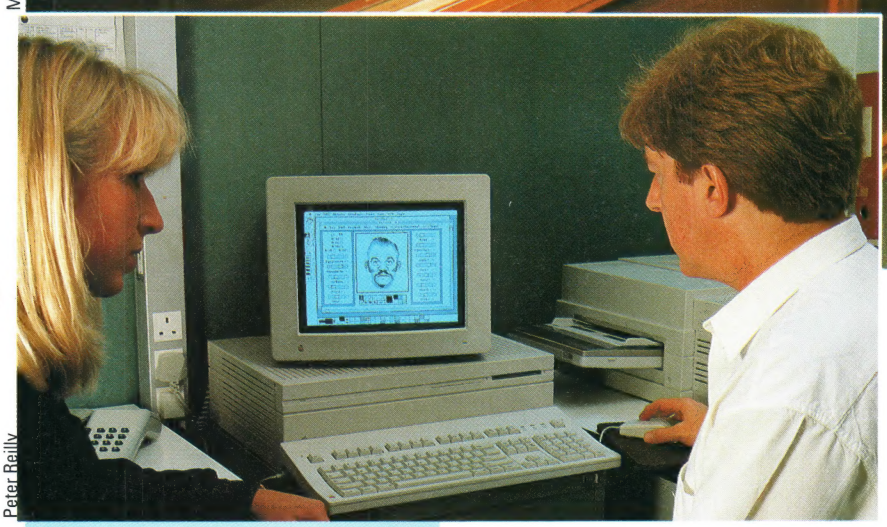
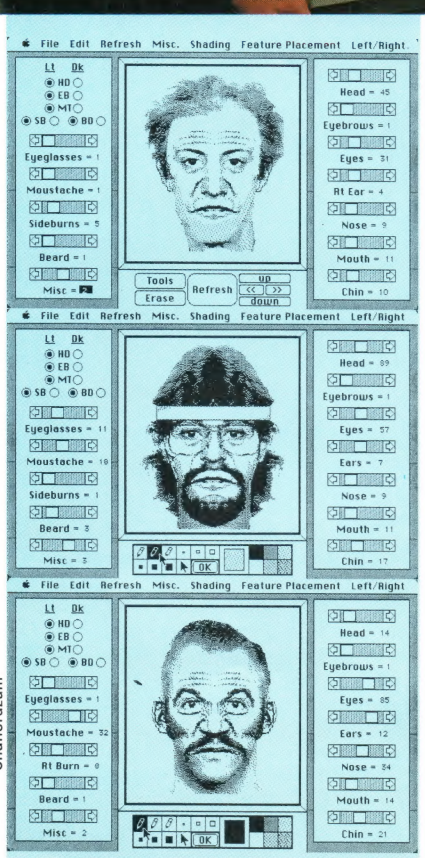
Metropolitan Police



Peter Reilly

Picking out faces *at an identification parade, safe behind a two-way mirror. The Mac-a-Mug system (inset), which can be used by a civilian as easily as by a trained police officer, is already in operation in Canada and the USA. A similar system could replace Photofit.*



Shaherazam

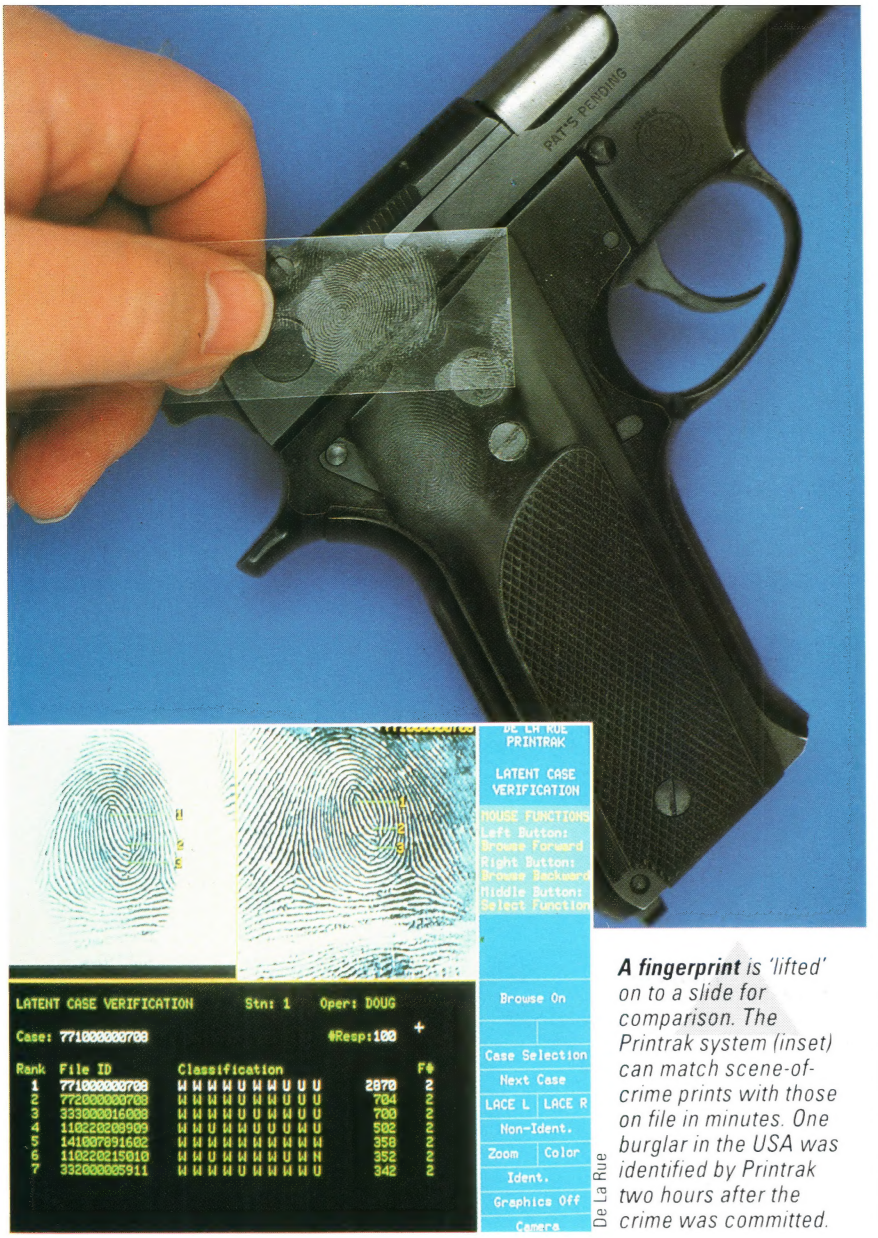
IDENTIFYING THE CRIMINAL

- PHOTOFITS
- FORENSICS
- FINGERPRINTS

YOU ARE WALKING ALONG the High Street, when two men suddenly burst out of the Post Office, each of them holding a bag and brandishing sawn-off shotguns.

You hide in a shop doorway, but as the men run down the street, one turns his head and looks straight at you. For that split-second, you see his face clearly. Through no choice of your own, you have just become an eye-witness to an armed robbery.

Any witness to a robbery will probably be questioned by the police, asked to provide a statement, and will then be asked to try and describe the robber he or she saw. Most British police forces use a



De La Rue

***A fingerprint** is 'lifted' on to a slide for comparison. The Printrak system (inset) can match scene-of-crime prints with those on file in minutes. One burglar in the USA was identified by Printrak two hours after the crime was committed.*

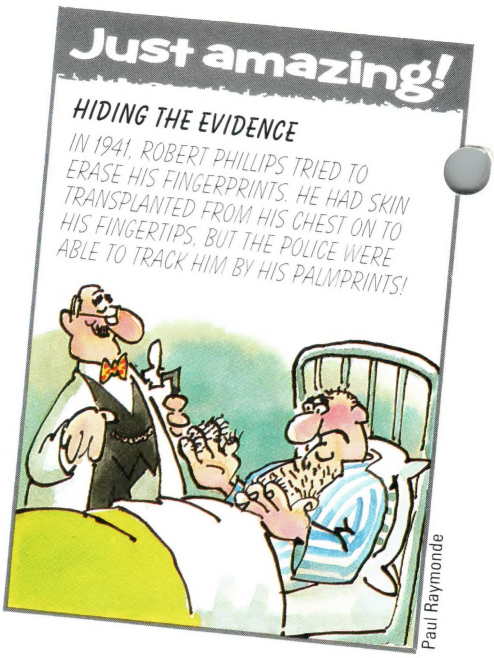
system called the Photographic Facial Identification Technique, or Photofit. The male Photofit set alone contains over 550 examples of hairstyles, eyes, noses, mouths and chins. By putting these features together in different combinations, it is possible to construct over 100 million different faces.

However, most witnesses only catch a fleeting glimpse of a face, often from a distance, and sometimes at night. Trying to remember one face from the hundreds we see every day, and keeping the image fresh in our minds is no easy task. Also fitting together the different Photofit cards can sometimes be confusing. To remedy this, a number of systems have been invented on computer, which are very much more versatile.

FINGERPRINT TYPES

1 2 3 4

There are four main types of fingerprint. **1** Arches, which make up about 5% of all prints, **2** loops, accounting for about 65%, and **3** whorls and **4** composites, about 15% each. Arches are further sub-divided into plain and tented arches. Loops are also sub-divided into radial and ulnar loops.



Paul Raymonde

Although they work on the same principle as Photofit, the computer systems are able to merge the different features together to form a full face. One disadvantage of Photofit is that the finished face looks something like a jigsaw, and is only in black-and-white.

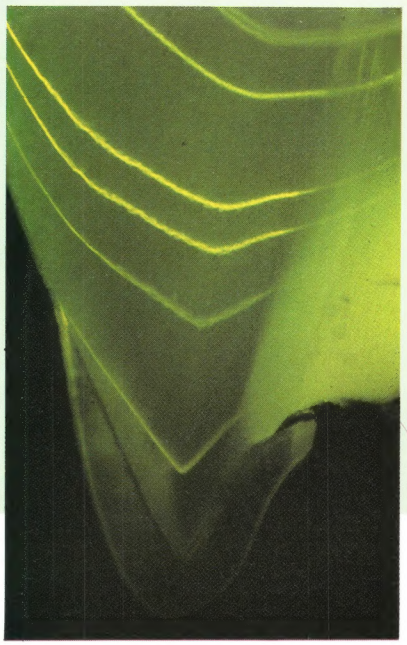
Faces on disk

One of the first of the new generation of computer systems is called Videofit, and is used by the BBC's *Crimewatch UK* programme. The system is very expensive but it is highly versatile. It uses colour, can produce a multitude of different flesh tones, and can add stubble or acne, or even a wig – and make it look real or false, just as the wit-

De La Rue

***The Printrak matching system** checks fingerprints on file. One person may have prints of more than one type: the suspect's prints shown has composites on his left thumb, and whorls on his left index finger.*

FORENSIC DENTISTRY



Tooth enamel is the hardest substance found in the human body. Consequently, the teeth survive longer after death than flesh and bone. All dentists keep detailed records of their patients' teeth: the shape, position and condition are all catalogued. When evidence is required in order to establish the identity of a murder victim, the police first compare the dental pattern of the corpse with records of missing persons in their computer system.

Also a chemical called tetracycline can be added to the victim's teeth, which highlights the growth lines. In the same way as the rings inside a tree-trunk indicate its age, these fluorescent lines show how old the tooth – and therefore the victim – was.

ness remembers. If the witness saw the face under street-lighting, Video-fit can even simulate this, casting shadows across the face to highlight a long nose or sunken eyes.

A smaller-scale version of Videofit, designed to run on an Apple Macintosh computer, is called Mac-a-Mug. It is cheaper, and is even more versatile. The program itself is 1200K long, and consequently can store a great deal of information. It has 185 head shapes, 118 eyes and eyebrows, 66 noses, 46 chins and even 37 different types of moustache. With all the combinations, it is even possible to alter one side of the face only, to make one ear higher than the other. Mac-a-Mug or a similar system is likely to overtake the old method of albums of 'mug-shots' in local police stations, which don't have access to large and expensive computers.

Aside from consulting witnesses, police also test the scene of the crime for fingerprints, and other clues. Although the unique nature of every person's fingerprints has been understood for centuries, they only began to be used in the detection of criminals at the beginning of the century. Today, the National Collection located at Hendon contains over two and a half million sets of fingerprints.

Identifying the 'dabs'

Fingerprints left by a dirty hand or in blood are easily visible, but a second group, called latent, or hidden, prints, are invisible. Latent prints are the impressions left by sweat-moistened ridges of the hand on polished surfaces such as glass or metal, Their existence is usually detected by shining an oblique light on the surface and then dusting the area lightly with a brush dipped in aluminium powder. The prints can then be photographed and 'lifted' from the surface using a special transparent tape which can then be stuck on card for use as evidence in court.

Finding the print is only the first step. Now the police must try to find out to whom the prints belong. They are rarely lucky enough to find a complete set of 'dabs' at the crime scene but must work on the blurred impression of a single finger.

In these cases, a highly skilled technique known as poroscopy may be employed. This involves comparing the pattern of the individual sweat pores which, like the

***A lie detector** monitors the heart rate, breathing and perspiration. It detects any disturbance to normal body rhythms, caused by the extra adrenalin produced when a lie is told.*

Lafayette Instrument Co.

CLASSIFYING BLOOD

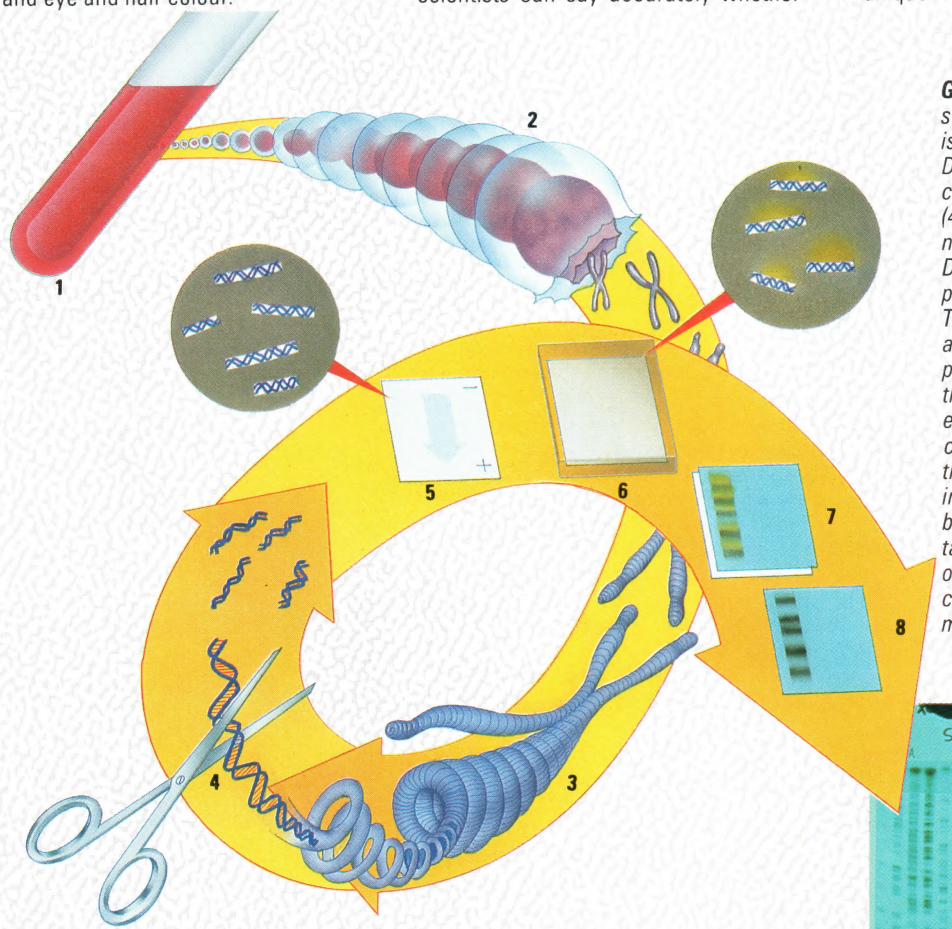
Spillage of blood is a common occurrence in violent crime, and the examination of bloodstains can give a great deal of information about the way in which the blood was spilt, and about the person who shed it.

Blood that is allowed to drip freely on to the ground leaves a highly characteristic pattern of drops and splashes, which is quite different from the pattern left by blood that has spurted from a wound. And because it is difficult to remove bloodstains at the scene of a crime, even the smallest trace that had dried into a corner would be enough to analyse for blood group. As well as analysis of the pattern of dripping blood, there is also a complex system used for the classification of different types of blood.

Under the ABO grouping system, there are four main blood groups. Each red blood cell has a thin shell which contains chemicals called antigens. Any red cell which has A antigens is in group A, any cells with B antigens are in group B. Those cells with both types of antigens are in group AB, and those with neither of them are classified as group O. In the UK 47 per cent of the population are in group O, 42 per cent are group A, 8 percent group B, and just 3 per cent group AB.

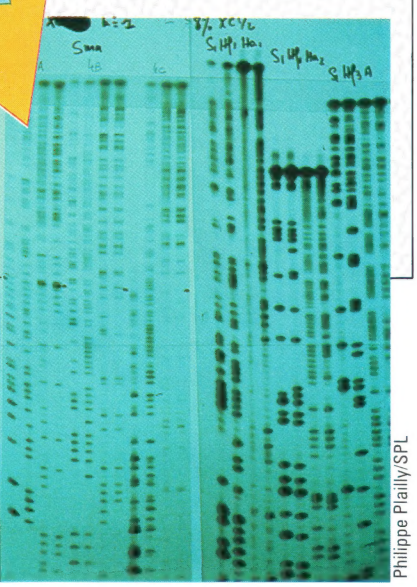
DNA (deoxyribonucleic acid) is a string of chemicals that is present in every single cell of the body. It contains all the information necessary to make a human being: as well as the correct numbers of arms and legs, it also contains such details as personality and eye and hair colour.

A large part of the DNA is the same for every human: two arms, one head, and so on. But it is the detail of hair colour, blood group and personality that is unique to each person. By comparing a suspect's DNA pattern with that of a sample found at the scene of the crime, scientists can say accurately whether the suspect committed the crime or not. Although many people share one or two DNA characteristics, only two people in every ten billion have identical DNA patterns. Since the entire world population is only five billion, it is safe to say that each person's DNA 'fingerprint' is unique.



Mark Franklin

Genetic fingerprinting *A blood sample is taken (1), and the DNA is extracted (2). Each strand of DNA is isolated (3), and chemically sliced into fragments (4). The DNA is transferred to a nylon sheet (5), and the parts of DNA that are unique to each person are made radioactive (6). The radioactivity shows up (7), and is developed on to an x-ray plate (8). The different plates for the suspect, the victim, and the evidence at the scene of the crime are compared. Since the DNA is present in every cell in the body, DNA taken from blood can be matched with DNA taken from skin, saliva, or any other body material without the chance of a mistake or mismatch being made.*



Philippe Plailly/SPL

ridge patterns themselves, are unique to the individual.

But whatever the method, the standards of proof remain the same – 16 points of similarity must be established between the prints found at the crime scene and those stored in the crime file to be sure of identification.

The way forward

All prints are now stored on microfilm, together with a series of code letters which uniquely describes each individual pattern. The 'Videofile' computer system is fed information on the print found at the crime scene and the Automatic Fingerprint Recognition system (AFR) then sifts out those prints which best fit the description. The operator can then compare the impressions on a special split-screen VDU to confirm the match.

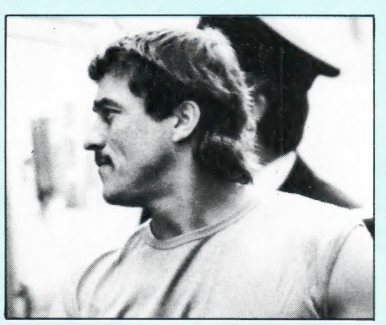
However, even more accurate ways to identify criminals are now being developed. Instead of using fingerprints, which have quite a high error possibility, scientists can now use the body's own microscopic building blocks – unique to each person – to pin down a suspect's identity. The process, called 'genetic fingerprinting', uses the unique design of DNA.

With genetic fingerprinting, then, a murderer could leave no fingerprints, no marks, or anything at the scene of the crime apart from an eyelash or some saliva – and this would still be sufficient to analyze and prove him guilty of the murder.

This type of fingerprinting has proved particularly successful as evidence in rape cases. Indeed, during 1988 eight convictions for rape or murder were secured in Britain and seven in the USA, based on DNA fingerprint system.

GENETIC *TEST CASE*

On 13 November 1987, Robert Melias was convicted in Bristol Crown Court of rape. He was the first person in the world to be imprisoned by genetic fingerprinting.



South West News

UNDERGROUND HOUSES | GEODESIC DOMES | PROFILE OF A NEW TOWN

BUILDINGS FOR THE FUTURE

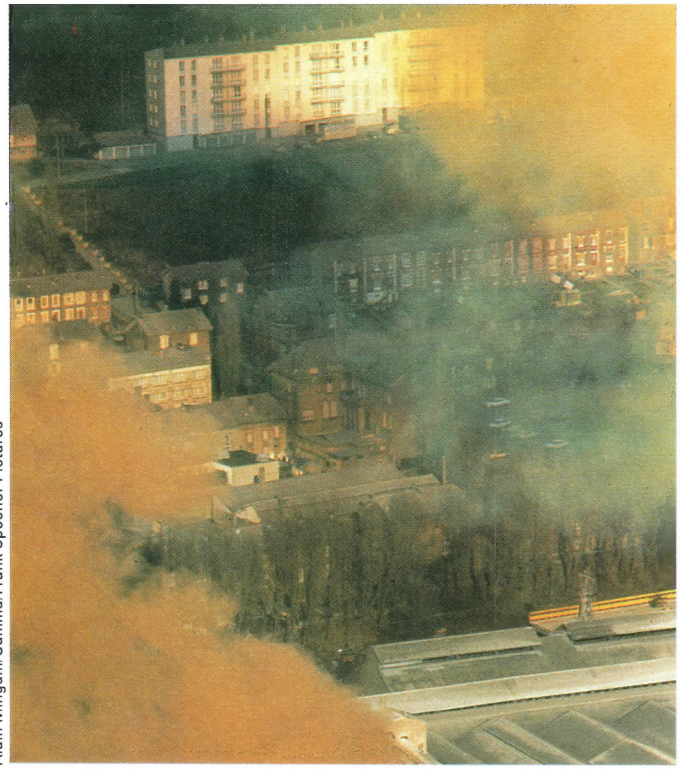
HOW WILL HUMANS BE living 30 years from now? Ten kilometres up in soaring skyscraper-cities? In caverns buried deep in the ground? Or in a series of huge globes, each holding millions of people?

One thing seems certain, the buildings and communities in which people spend much of their lives will be very different in years to come from the way they are today.

Buildings in the next century will have to be much more energy-efficient. Our current supplies of fuels are gradually running out, and with such a massive increase in

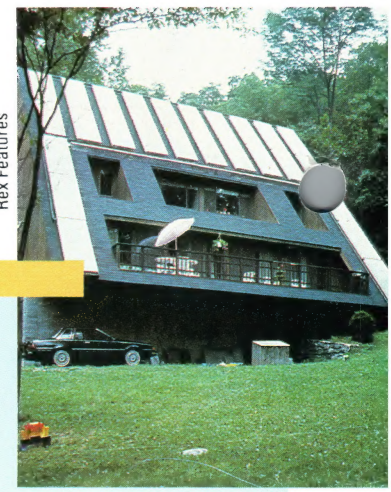
Rex Features

Lloyd's of London. *This magnificent structure of glass and aluminium houses 6,000 workers. The 14 floors, built around a central atrium, provide a temperature-controlled, well-lit environment for the building's inhabitants.*



Alain Mingam/Gamma/Frank Spooner Pictures

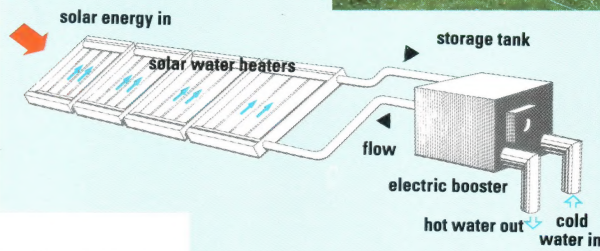
A thick brown smog *settles over the city. This kind of smog can cause chronic bronchitis, irritation of the eye, and severe breathing problems. As well as affecting humans, gases from industrial plants lead to long-term environmental damage.*



Rex Features

SUN ENERGY

A solar water heater uses no electricity – the water is heated only by the rays of the sun. Cold water enters from the main system and is piped to the solar panels.



Because the panels are made of special glass, they can get very hot indeed. While the water flows through panels, it is heated by the direct rays of the sun. When it returns to the storage tank, it is kept hot by a small electric booster unit until it is needed. These units are around 55 per cent efficient – that is, they lose a little under half the energy available.

population a great strain is being placed on the planet.

Another important factor is that, in almost every country, more and more people are moving into towns and cities. In trying to solve crucial urban problems such as crime, pollution, overcrowding, and traffic congestion, the appearance of our cities is likely to be transformed.

Future cities, although large, may include wide areas of parkland and woodland, extensive car-free zones for pedestrians and cyclists, and housing that is pleasant both to look at and to live in.

At the opposite extreme is the fear that many of the world's cities may be overwhelmed by problems such as pollution and fast-rising populations.

Yet such are the difficulties facing cities today that some architects and planners are suggesting a number of radical alternatives to the standard type of living accommodation.

Houses built today are generally well insulated and reasonably cheap to run. But they still depend heavily on electricity and gas made from fossil fuels – coal, oil and natural gas. Not only do these fuels, used in large quantities, irreparably damage the earth's atmosphere, but they are also set to run out in the next century. This will force scientists to come up with new designs for our homes and new ways of obtaining energy. But not all are futuristic dreams – some are already happening.

Living underground

Underground or 'earth-sheltered' houses are already popular in the United States and other countries. These take advantage of the natural insulating properties of soil. Three metres below the surface, the temperature stays between 10 and 20 degrees Celsius regardless of the weather above. Since very little heat can pass through its walls, an underground home is easy to keep warm in winter and remains cool even on the hottest summer day.

Underground houses have the extra advantage of blending in well with the environment. Often, very little of the house is visible from outside and many such homes could be built in an area without creating a 'concrete jungle'.

Visions of the future

Architect Paolo Soleri has spent years in the Arizona desert turning his ideas for a city, called Arcosanti, into reality. Since 1970, thousands of students and other volunteers have come to the desert to work on Soleri's project – to build a city within a single building.

Soleri calls his proposed com-

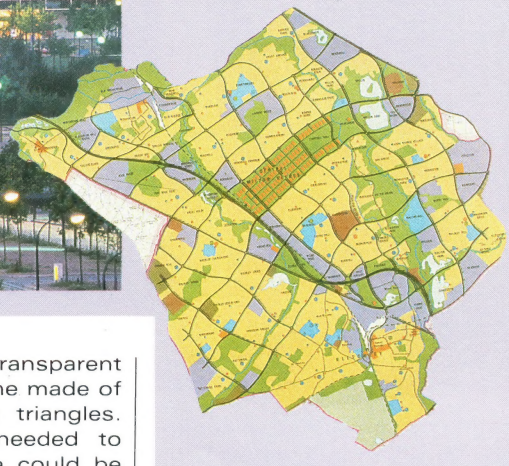
Paul Raymonde

An underground house *nestles into a hillside. In the foreground of the picture is a solar panel. Underground homes can be any size without becoming eyesores, and they are naturally insulated by the soil. Homes like this – although unusual – are increasingly popular in the United States.*

Esto

THE BEGINNING OF A NEW TOWN

A new town, such as Milton Keynes in the UK (left and below), rarely starts from scratch, but is likely to be built on the site of a village. The initial considerations in each case tend to be different – in some instances, the drainage system might be a first priority and in others, a new road system.



'The Creative Company Milton Keynes'

The next important task is to build a balanced community, encouraging industry to support the venture and people to support the industry. And once the local council has played its part with commercial grants and subsidized housing, developers will move in and build private housing which will add yet more people.

munity an 'arcology', that is, a blend of architecture and ecology. His goal is to create a place where thousands of people can live and work without the usual stresses of urban life. So far, only a fraction of the project is complete, but by attracting visitors to the site, has shared with others his vision.

Dome city

A very different futuristic scheme is the brain-child of famous American architect Buckminster Fuller. Take a city, suggested Fuller, and totally enclose it within a transparent 'geodesic' dome – a dome made of interlocking shapes like triangles. No beams would be needed to support it, so the dome could be almost any size. Protected by their clear bubble of special plastic, the city's inhabitants would never have to suffer from bad weather. On hot summer days, the dome's panels could be darkened like sunglasses to shield the city from the sun's glare. In winter, the glass would become clear again to let through the sun's rays for extra warmth.

Surrounded by protective domes, communities could be set up almost anywhere on Earth, from the frozen polar ice caps to the searing hot deserts. However hostile the conditions outside, the people inside their environment-controlled dome could lead a normal, pleasant life.

Another strange idea of Fuller's is for cities that float in the sky. Each of these aerial communities would be built within a geodesic ball a

HOME IN A DOME

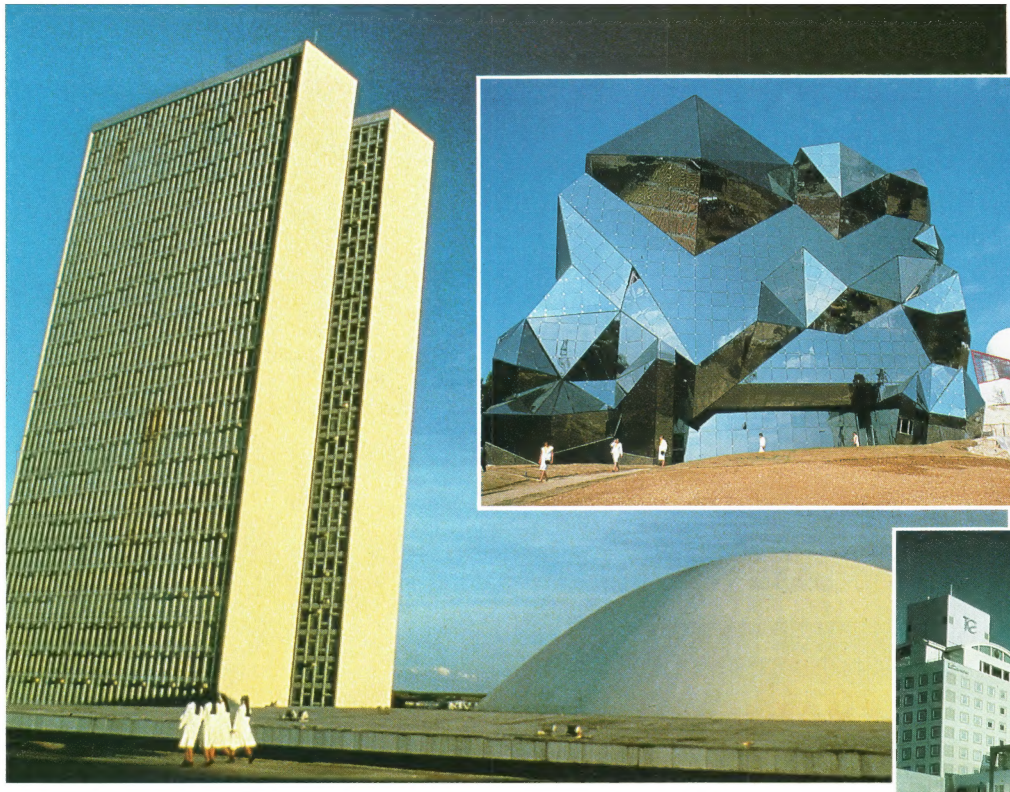
Hutchison Library

Geodesic domes – domes that are made of interlocking shapes and can stand up without supporting beams – are already in evidence as structures in public places and exist as houses in some remote areas. They are simple to build, solid, and they are also light and airy inside.

These domes, in the Arizona desert in the United States, have light-coloured surfaces to reflect the glare of the sun, and also have chimneys to keep a cool airflow inside. Their squat shape is a good protection against the tornadoes and dust-storms that can sweep across the desert.

Building Arcosanti *in the middle of the Arizona desert. This complex city-structure was conceived on paper in the 1960s by Paolo Soleri, and was started in 1970. While it is now open for daily tours by enquiring visitors, this futuristic development will eventually house an experimental community in hive-like domes.*

Cosanti Foundation



Rex Features; inset Gamma/Frank Spooner Pictures

Poitiers, the city *set on a hill above the rivers Clain and Boivre in France, has attracted invaders, settlers and visitors for centuries. Now this balcony town plays host to a huge theme park which includes 'Futuroscope', an exhibition hall focused on technology.*

Rex Features

Science City, *in Japan, was built to house the booming new technology industries. There is no public transport, and the 140,000 inhabitants live and work in computer-controlled enviroments. Schoolchildren use computers to work on, and are not forced to take any exams.*

kilometre or more across. When the sun shone on the city-sphere, the air inside would be warmed, and would expand, so that some of it would be pushed out of openings in the ball. Then the whole structure would weigh less than the surrounding air and would lift up like a hot-air balloon. Provided the air inside remained warm, the structure would stay aloft, drifting endlessly around the Earth like a cloud.

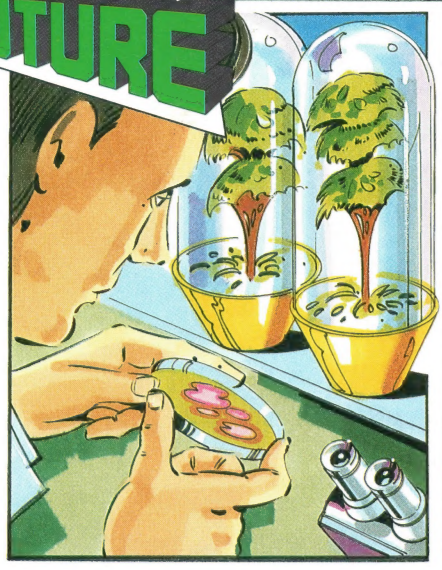
A futuristic city-shape, *already in existence. Brasilia, the new capital of Brazil, was built in the 1970s from scratch in a clearing in the Amazonian jungle.*

Planetary citizens

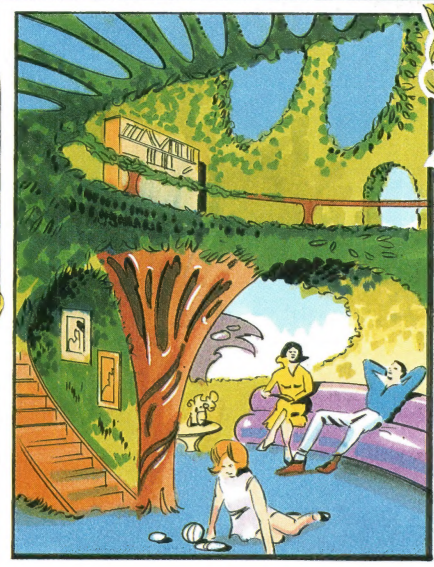
Because of vastly improved communications and transport, the old barriers between nations are gradually breaking down. Instead of belonging just to some small community, or even a large city, we are all becoming inhabitants of a 'global village'. Jetliners fly us halfway around the world in just a few hours, whereas it used to take weeks or even months to cross the ocean. By telephone or satellite television we can be instantly kept in touch with what is happening almost anywhere on the planet.

INTO THE FUTURE

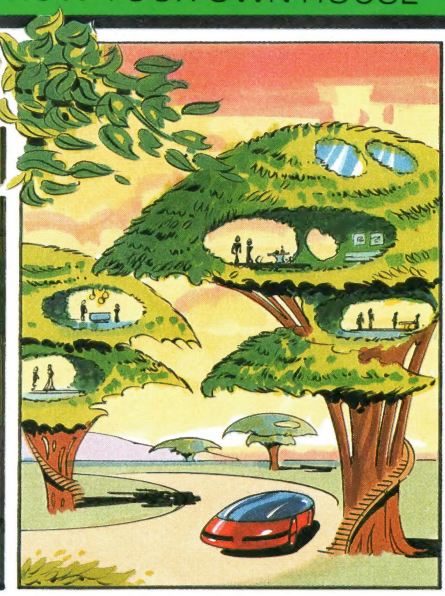
GROW YOUR OWN HOUSE



▲ *Genetically-engineered plants may be the houses of the future. Instead of being cut from trees, lumber could be grown in the laboratory from cultures of wood cells.*

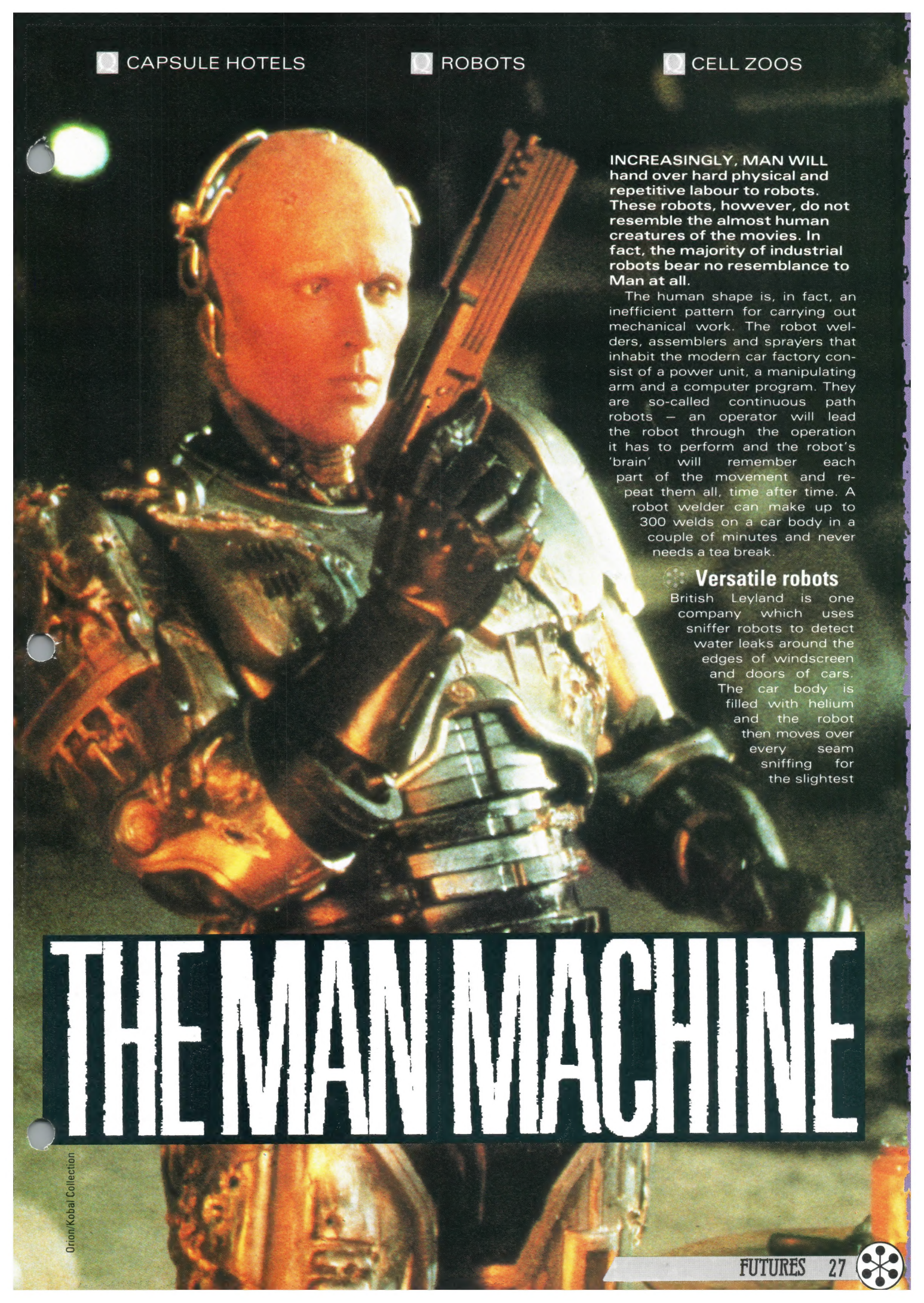


▲ *From that, the engineered seeds could be planted. They will already contain all the information for creating rooms and internal walls with doors.*



▲ *When fully grown, the tree will become a living house. It will clean the air, recycle water and store solar energy through photosynthesis.*

Lawrence



THE MAN MACHINE

INCREASINGLY, MAN WILL hand over hard physical and repetitive labour to robots. These robots, however, do not resemble the almost human creatures of the movies. In fact, the majority of industrial robots bear no resemblance to Man at all.

The human shape is, in fact, an inefficient pattern for carrying out mechanical work. The robot welders, assemblers and sprayers that inhabit the modern car factory consist of a power unit, a manipulating arm and a computer program. They are so-called continuous path robots – an operator will lead the robot through the operation it has to perform and the robot's 'brain' will remember each part of the movement and repeat them all, time after time. A robot welder can make up to 300 welds on a car body in a couple of minutes and never needs a tea break.

Versatile robots

British Leyland is one company which uses sniffer robots to detect water leaks around the edges of windscreen and doors of cars. The car body is filled with helium and the robot then moves over every seam sniffing for the slightest

Orion/Kobal Collection

and able to afford bigger apartments or a house in the country.

As well as sperm banks, life may be stored in cell banks, for future cloning by genetic engineers. As the human population increases in size, so Man is using up available land for crop use and wildlife is being pushed ever closer to extinction. No ordinary zoo could hope to begin to deal with the problems of conservation in more than a superficial way. Scientists are predicting cell-zoos where genetic material from a large proportion of known animal species

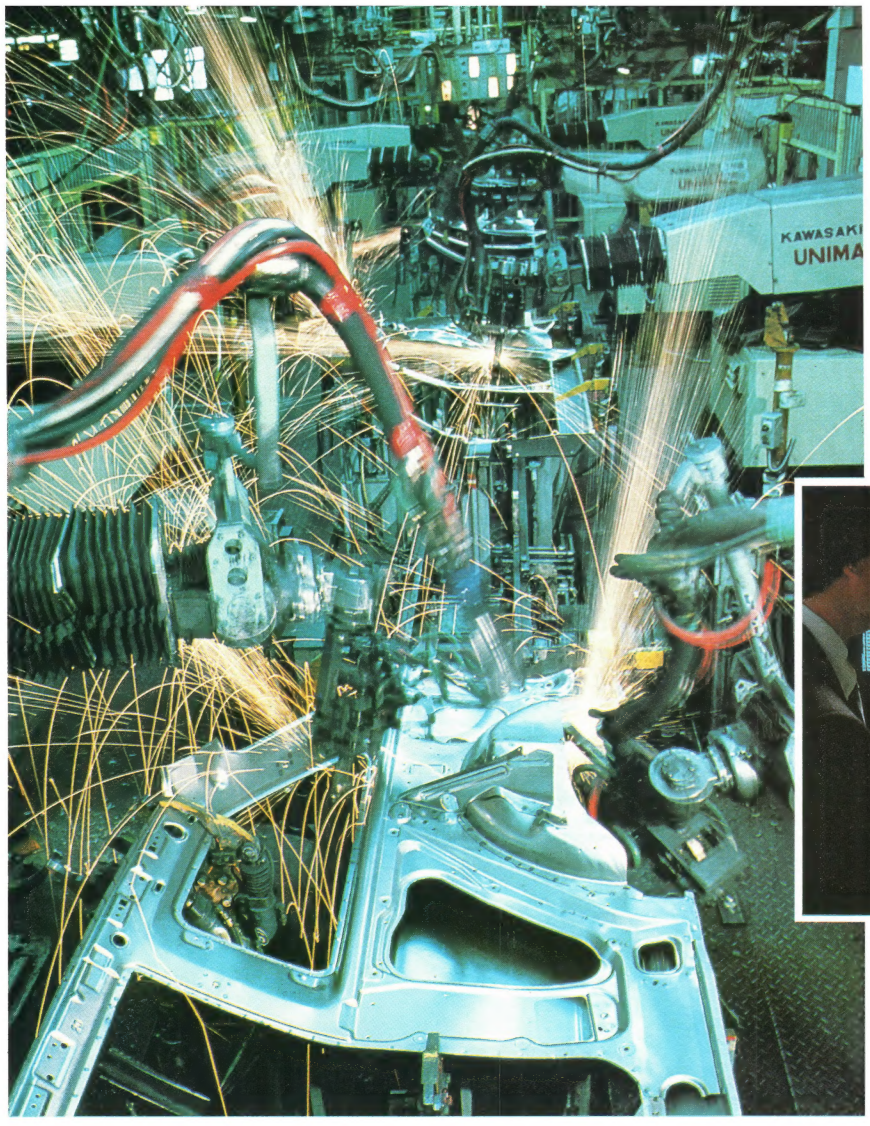


ABB Robotics Ltd

Rex Features

Cars are made by robots, *which weld body parts together as they pass along on a conveyor belt. Human labour has been virtually eliminated from most car production lines. Inset, the robots are designed on computer.*

COMPUTER CAR 2000

Volkswagen

Cars of the future will take the stress out of driving. Cars will be installed with an electronic system, which will enable them to travel at high speed, nose to bumper, without fear of collision. As soon as the car is on the guide track on the centre of the road the driver can sit back and watch an in-car video or snooze.

Laser sensors will control the distance from the car in front and respond to underground indicators that replace traffic lights. A computer will ensure the vehicle follows a programmed route to the required destination.

trace of gas escaping with its sensitive nose.

In the future, robots are likely to be programmable systems rather than individual, one-job units. A programmable house system will clean itself, produce meals, open and close shutters and curtains, regulate light and heat, and wake up the humans in the morning. Anything resembling a stainless steel butler in physique will be strictly to amuse visitors.

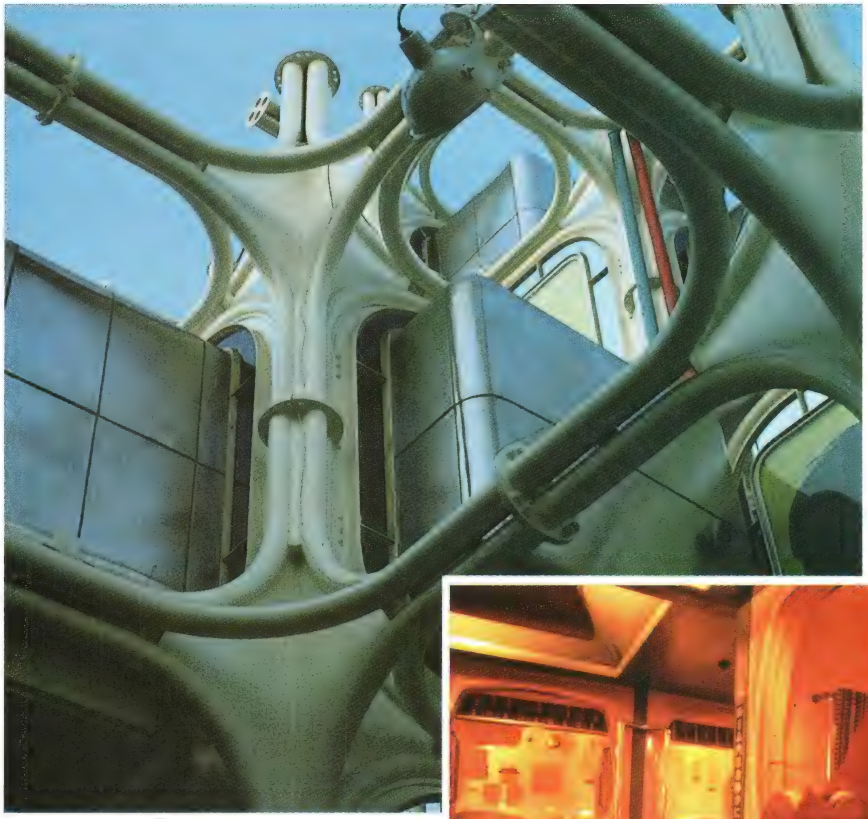
Running out of space

Robots will not be able to help humans deal with the chronic overcrowding, which is going to become a way of life for many, if predictions are true. With a world population of ten billion or so from the mid-21st century onwards and with over half this number inhabiting cities, city space will be at a premium. People may marry or live together in order to share apartments, but it will not pay them to have children. Many will wait until later in life to start families.

To guard against the possibility of reduced fertility, the likelihood of which increases with age, there may be an increased use of sperm banks. Young men would deposit sperm in a named account, so that it can be used when they are older,

Lowell Georgia/Science Photo Library

Robot waiters *always have a friendly word for customers, and never forget an order. Built-in cameras and ultrasonic rangefinders enable them to avoid bumping into people.*



Architectural Association

A prefabricated steel frame *is capable of holding over a hundred dwelling units. These are factory-made with in-built bathrooms and stereos. The units are slotted into the frame as required.*

I. Wright/Sunday Times

Room capsules *in the New Rubia hotel in Osaka, Japan, are 183cm deep, 91cm high and 76cm wide. Made of fibreglass, they provide small but cheap accommodation for those who only require a bed for the night. The hotel management can squeeze in four times the number of guests that could be held in a conventional hotel. In return, they charge only a quarter of the price.*

will be frozen and stored. If, as predicted, the human population shrinks again, from the 26th century onwards, the stored material can be used to clone entire species back into existence, and the animals will be able to return to the wild to rebuild their numbers.

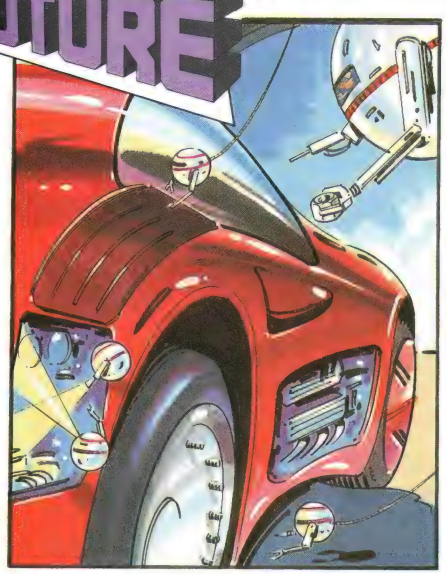
Man may adapt to the crowded urban conditions better than he imagines. The Japanese are probably the most crowded nation on Earth. The population of over 120 million lives crammed into a few coastal cities for the main part. The Japanese countryside is too wild and mountainous to support urban spread. To try and cope with space restrictions, modular apartment blocks have been built.

Each apartment is a box, about the size of a shipping container. Inside, each one is a compact and moulded design. The modules are brought on site on trucks, in off-peak traffic periods, then lifted by crane and slotted into place on a central support column. Scaffolders bolt them into place, and service tubes, containing electricity and drainage links, are attached to the central system in minutes.

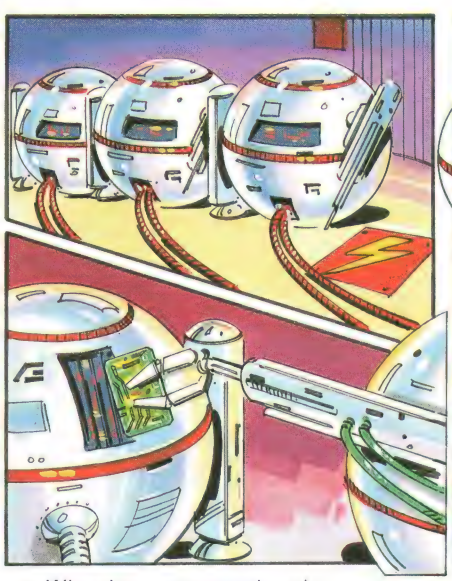
Capsule hotels are even more compact, and designed for Japanese businessmen staying in town overnight. The hotel consists of banks of cupboard-like sleeping units, complete with fitted radio, TV and video, hi-fi, and telephone, plus a futon bed. The room capsules are only sufficiently high to sit in, and are stacked three-high, in rows, like cells in a beehive. TV and video screens are built into the ceilings, so films can be watched by

INTO THE FUTURE

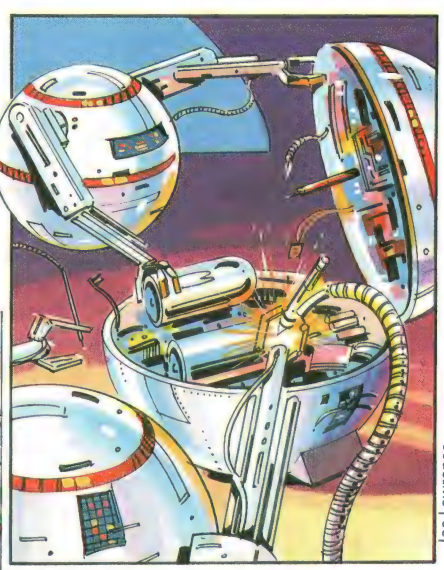
MINIATURE ROBOTS



▲ *A microrobot will be small enough to go into car engines, electrical systems and air ducts to inspect them for faults, and to repair and clean them from the inside.*



▲ *When its energy runs low the microrobot plugs itself into a power supply. With the help of other robots it will clean, service and repair itself.*



▲ *Microrobots will be able to replicate themselves, so humans would no longer play a part in the building or maintenance of their robot helpers.*

Joe Lawrence

ELECTRO-MAGNETIC MAN

G. Hadjo, CNRI/SPL

Future medicine is likely to explore an aspect of the human physiology that has long been a mystery – the effects of electric and magnetic fields on the body. A Russian scientist called Semyon Kirlian devised a method of photographing the electric field produced around objects when they are placed near a metal plate charged to a high voltage. Some people think that the Kirlian patterns formed around a human hand may somehow indicate the person's state of health. But most scientists believe that variations in the moisture content of the skin are the main cause of variations in the patterns produced.

Electro-magnetic fields applied to the body have already been used to speed up healing processes, such as the regeneration of bone tissue. And the body may use electrical effects as part of its self-healing system. If so, a way of stimulating this system to hasten healing may be discovered.

the occupants while lying down.

As Man's body becomes less muscular, literally shrinking from lack of use, he may increase its robustness with bionic armour. He could even end up as a type of cyborg – a man-machine – with original body and manufactured parts intimately connected, or even growing together. However, with his improving skills in genetic engineering, Man may be able to forestall a weakening of the body by inserting genetic material into his own cells, and keeping a strong skeleton and powerful muscularity a programmed part of the species.

Biochip revolution

Where manufactured and organic material is likely to come together most spectacularly is in the field of miniaturized information storage. Computer scientists are excited by the idea of the biochip, a three-dimensional information chip controlled by proteins, instead of the logic gates and circuits of the standard flat silicon chip. Organic molecules in the biochip will give it the computing power of a living cell.

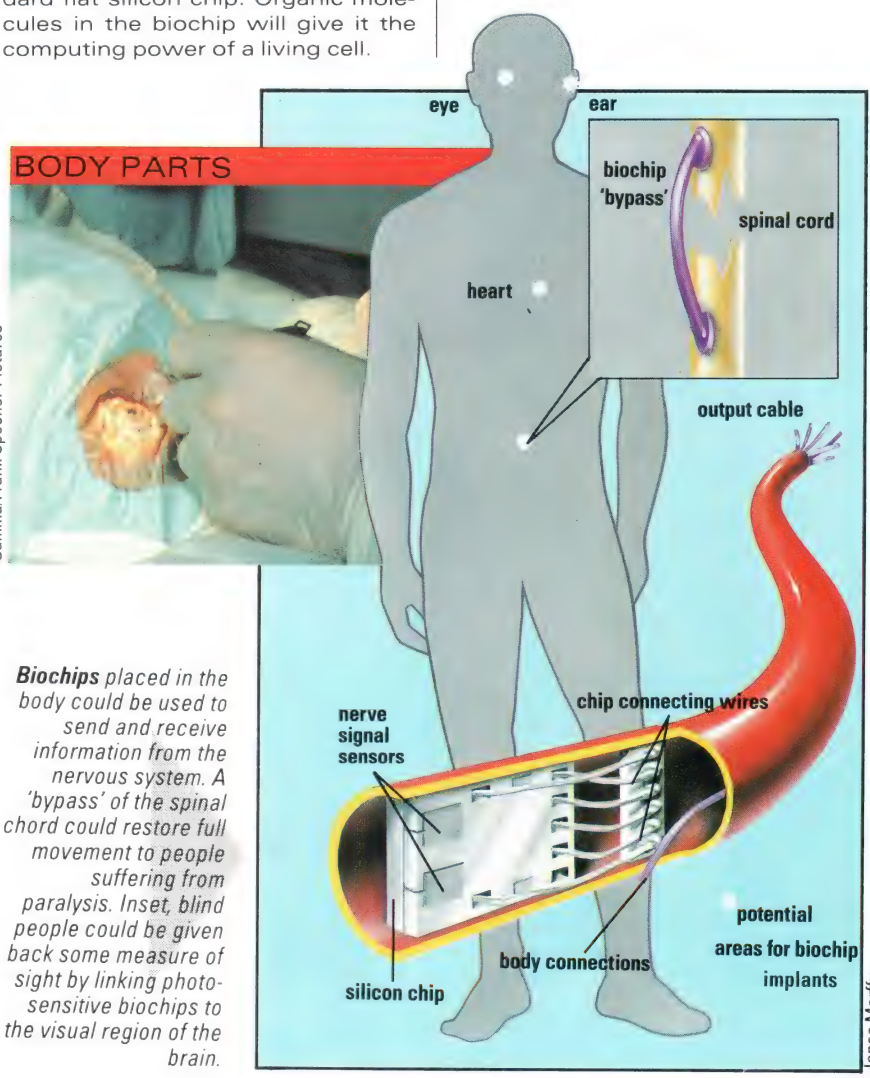
Prototype biochips have been used as chemical detectors for analyzing liquids. They transmit calculations as electrical signals, and are made of silicon and an enzyme.

Repairing man

Medical biochips could be used to transmit information from inside the human body. They could, for example, be inserted into the bloodstream and relay information on the concentrations of various substances in the blood. The medical potential for biochips is enormous. Hearing and sight might be able to be restored by sound- or light-sensitive biochips, which could send nerve-pulse messages to the brain.

The biochip is one way of overcoming the limitations of the silicon chip. With stupendous information-handling abilities, biochips could have their own learning memories. They could build up a fund of experience, which would enable them to approach ever more complex calculations, and they might even be able to create improved versions of themselves. If that happens, then Man with integral machine parts in his body might one day find himself challenged by the machine with living organisms incorporated into its make-up.

BODY PARTS



Gamma/Frank Spooner Pictures

Janos Marffy

Biochips *placed in the body could be used to send and receive information from the nervous system. A 'bypass' of the spinal chord could restore full movement to people suffering from paralysis. Inset, blind people could be given back some measure of sight by linking photo-sensitive biochips to the visual region of the brain.*

Just amazing!

LOSING FACE

ORTHODONTISTS RECKON THAT WITHIN A FEW MILLION YEARS MAN WILL LOOK VERY DIFFERENT. HE WILL HAVE SMOOTH SKIN, NO HAIR, AND, BECAUSE HE WILL EAT SO MANY REFINED FOODS, HE WILL HAVE A SHRUNKEN JAW AS WELL.

Paul Raymonde

FLYING COMPUTERS

***Large, advanced cathode** ray tube displays on the A320 have replaced the traditional dials and gauges. The Centralized Fault Display System displays diagnostic data on multi-purpose control and display units in the cockpit, and the crew is constantly fed updated data by the synoptic displays on the Electronic Centralized Aircraft Monitor (ECAM)*

Airbus Industrie/APL

DOZENS OF DIALS, SWITCHES and controls confront the pilot of the latest design aeroplanes, sending out a wide range of constantly changing information, which he must sort out – sometimes within seconds.

Computers can do a great deal to help to relieve the pilot's workload. Computers are able to monitor and control engines, assess weapons systems and potential targets, and deal with navigation. Quite often they even take over and fly the aeroplane.

The European Airbus A320 is a good example of modern aviation technology. The most significant innovation is its 'fly-by-wire' control system. In a traditional airliner, the pilot and co-pilot have control columns that are mechanically linked to the aircraft's various control surfaces.

The A320, on the other hand, dispenses with the mechanical links. The pilots have small control columns that send electrical signals via a computer system. Wires have replaced the mechanical links.

Computer control

The pilots' commands are interpreted by a flight computer, which then implements the appropriate changes to the control surfaces, based on its pre-programmed record of the aircraft's behaviour. Changes to the way the aircraft handles and performs can be made by amending the computer program.

Each computer system has at least one back-up. The computer equipment is produced by different suppliers and the programs for each computer are written by different teams. Such precautions avoid the possibility of two computers suffering the same design failure.

Computer control enables a number of sophisticated protection systems to be fitted. One of these is called the alpha-floor protection, which automatically brings in full engine power when the aircraft reaches a specified angle of attack. Another is called the alpha-limit feature, which selects the best angle of attack to generate maximum lift when the pilot climbs.

The computer control system aboard the A320 briefly fell under suspicion following the crash of an aircraft at Mulhouse, France, in June

Airbus Industrie

The computer flight *control system in the A320 responds to movements of the sidestick (inset). There are two computers that control the elevators and ailerons (the hinged flaps on the rear edge of the wings) and three that control the elevators and spoilers. The computers make it impossible to overspeed, overstress or stall the A320.*

1988. It now seems that pilot error was to blame. The A320 was performing a low-level fly-past at an air show, but failed to pull out of its climb quickly enough. It crashed into a forest beyond the end of the runway, killing three people. The alpha-floor protection system, which might have saved the A320, does not operate at very low altitude. Below 30 metres, the computer assumes that the aircraft is coming in to land and consequently does not engage full power.

The A320's navigation is also handled by a computer. The system is programmed to follow the most fuel-efficient flight profile, from take-off to landing.

Current computer-assisted aircraft contain about 50 different computers and microprocessors. Each of these is allocated to a specific task or group of tasks. The aircraft of the mid-1990s and beyond may be equipped with a single, powerful, central computer.

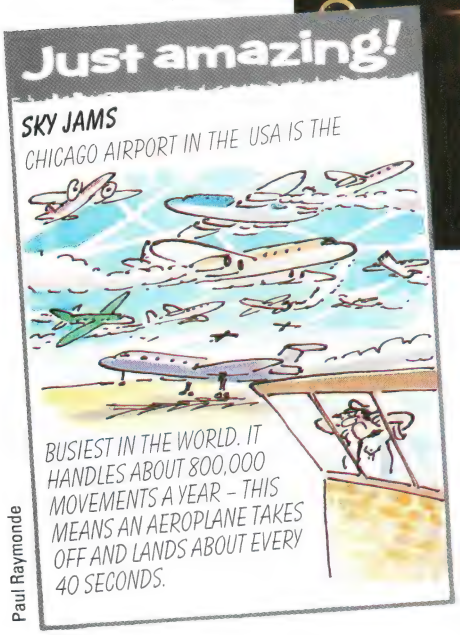
An alternative to the fly-by-wire system is the fly-by-light aircraft. Instead of sending electrical signals by wire, messages would be sent by laser beams along optical fibres. This is of particular interest in military avionics, as an electrical signal passing along a wire generates a magnetic field. A potential enemy can detect this field and interfere with it, causing much disruption and confusion. With optical fibres, the problem would not arise.

Air traffic control is another area where more powerful computer systems will be needed in the future. Already, at times during the summer months, some airports are unable to cope with more flights. Powerful air traffic control computers could overcome this problem.

Air traffic control *is being increasingly computerized in order to cope with the extremely heavy load of international civil aviation.*

Image Bank

Just amazing!



Paul Raymonde

THE BLACK BOX

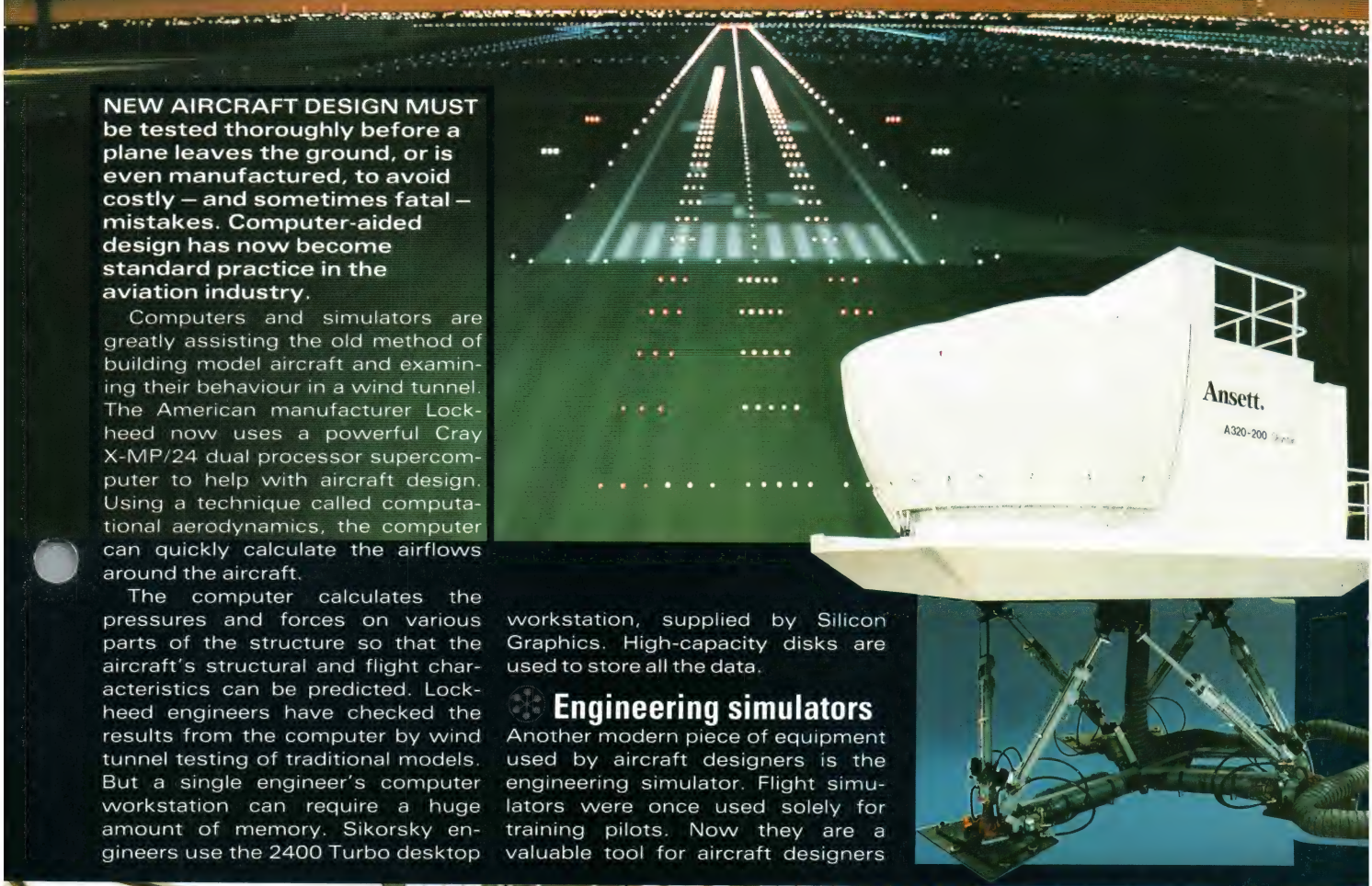
Reports of air accidents carried by the various news media often refer to the 'black box' flight recorder. This is the device that records what happened to the aircraft up to the moment just before its crash.

In fact, the term black box is inaccurate. Firstly, there are not one, but two boxes. The first is the Flight Data Recorder, or FDR, which records various instrument readings and control settings throughout the flight. The second is the cockpit voice recorder, or CVR, which records voices and other sounds in the cockpit. The instruments store 25 hours' worth of information.

Secondly, the FDR is not black at all. It is bright orange, which makes it much easier to find after a crash.

Smiths Industries

TEST PILOT



NEW AIRCRAFT DESIGN MUST be tested thoroughly before a plane leaves the ground, or is even manufactured, to avoid costly – and sometimes fatal – mistakes. Computer-aided design has now become standard practice in the aviation industry.

Computers and simulators are greatly assisting the old method of building model aircraft and examining their behaviour in a wind tunnel. The American manufacturer Lockheed now uses a powerful Cray X-MP/24 dual processor supercomputer to help with aircraft design. Using a technique called computational aerodynamics, the computer can quickly calculate the airflows around the aircraft.

The computer calculates the pressures and forces on various parts of the structure so that the aircraft's structural and flight characteristics can be predicted. Lockheed engineers have checked the results from the computer by wind tunnel testing of traditional models. But a single engineer's computer workstation can require a huge amount of memory. Sikorsky engineers use the 2400 Turbo desktop workstation, supplied by Silicon Graphics. High-capacity disks are used to store all the data.

Engineering simulators

Another modern piece of equipment used by aircraft designers is the engineering simulator. Flight simulators were once used solely for training pilots. Now they are a valuable tool for aircraft designers

Redifusion Simulation Ltd.

***Computer-aided** simulators are used extensively to test new aircraft design. Computers can evaluate an aircraft's flight characteristics and predict how it would react under a whole variety of circumstances without it ever leaving the ground.*

Rolls-Royce plc

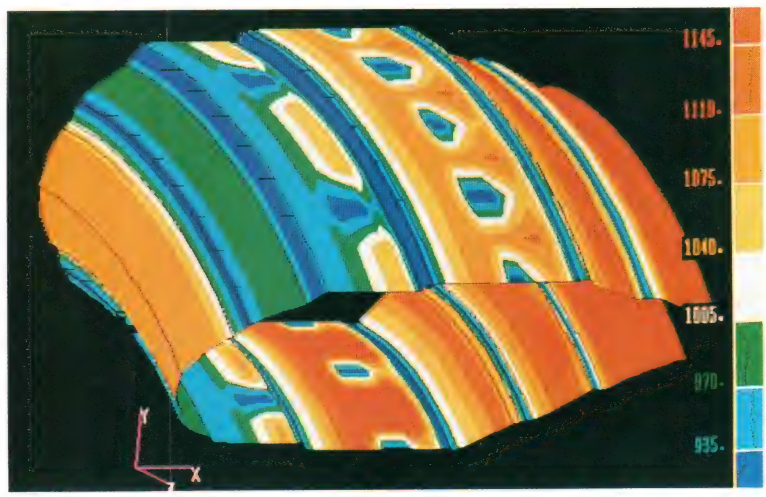
Computer-aided design *and manufacture (CAD/CAM) means that aeroplane engines are designed more efficiently. At Rolls Royce, the plane parts are made by micro-computer controlled automatic machines.*

as the real thing. Often, the only way to tell that you are in a simulator is to look out of the window. Although the hardware is accurate, the view from the cockpit is usually nothing more than a cartoon-like representation of the real world.

Producing an artificial landscape and making it change in response to the movements of the simulated aircraft takes a phenomenal amount of computer power. Some of the technology used in flight simulators has much in common with arcade video games.

as well. Almost the entire process of designing an aircraft can now be handled by the computer-driven engineering simulator.

With conventional aircraft design, the last component to be added was often the pilot. Engineers had to build a full-sized prototype aircraft before a test pilot could find out how easy, or difficult, the machine was to fly. This could lead to expensive mistakes. But simulators use the pilot's comments very early in the design process.



Rolls Royce Plc

Temperature patterns *in a jet engine are predicted by means of a computer simulation before the engine has been made. The predictions are later tested on the real engine by means of heat-sensitive paints.*

The characteristics of a proposed new aircraft can be fed into a computer that is used to drive a flight simulator. A pilot then has the chance to 'fly' the new aircraft in the simulator before the aircraft is ever built. Important design changes can, therefore, be made at an early stage.

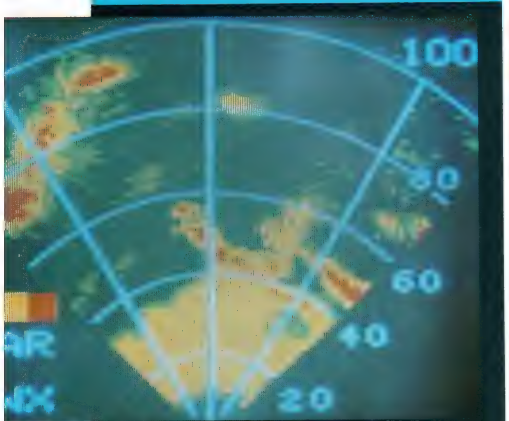
A good example of this is the development of the Sikorsky/Boeing Vertol LHX light helicopter. Designers were not sure whether one or two pilots would be needed to fly the helicopter in certain attack modes. The simulator enabled a single pilot to attempt such attack profiles before a final design decision was made.

Cockpit control

A simulator is an expensive piece of equipment. The visual system alone can cost $2 million for a civil aircraft simulator, and $10 million for a military system. The main flight simulator used in the LHX development programme cost $25 million.

A flight simulator duplicates all aspects of a real aircraft cockpit. All of the instruments and displays are driven by a computer, but they behave in exactly the same manner

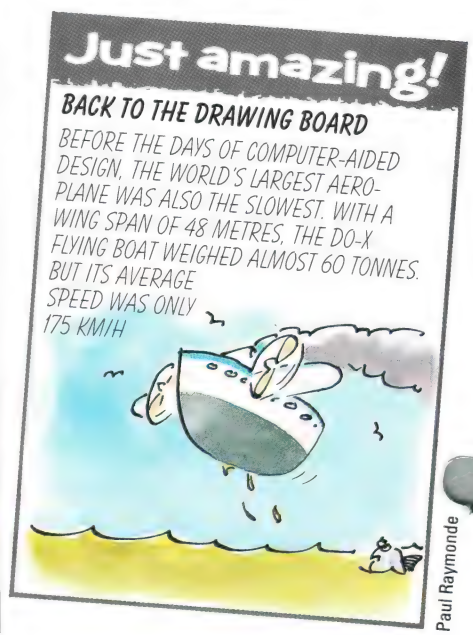
WEATHER WATCH



Aviation Picture Library

Accurate weather forecasts can save airlines a lot of money. If pilots can avoid bad weather and find favourable tail winds, the savings in both time and fuel are considerable. A 1986 report from the UK Committee of Public Accounts showed that on the North Atlantic route alone, weather forecasting saves airlines £60 million every year.

In the UK, weather forecasts for civil aviation cost £17 million per year. Most of this is recovered by charging aircraft that enter UK airspace. The Meteorological Office in Bracknell, Berkshire, is responsible for Britain's weather forecasts. The Office costs about £80 million per year to run, £33 million of which is provided by the Government.



Paul Raymonde

- WEAPONS
- ACK
- ER HAVOC

CHEMICAL WARFARE

***Ravaged trees** stand as graveyard tombstones, commemorating a Brazilian forest. Chemicals sprayed to clear the land in 1984 – and they may have included 'Agent Orange', used by the USA during the Vietnam war – left at least 42 people dead.*

Morel/Gamma/Frank Spooner Pictures

CHEAPER AND SIMPLER THAN nuclear weapons, and without the devastating after-effects, poison gases and germ weapons have been called the 'poor man's deterrent'. Despite attempts to control them, these weapons of mass destruction could be the basis of the next arms race.

Most countries are signatories of the Geneva Protocol, which bans the use of chemical weapons, though not their possession. A similar agreement in 1975 banned the use of biological weapons, such as viruses and toxins. Chemical weapons have been used in recent years, most notably in the war between Iraq and Iran, but also in Afghanistan by the Russians, and by the Egyptians in the Yemen in 1966-67.

Chemical weapons

There is a wide range of chemical weapons and they work in many different ways. Some are designed to kill, some to cause temporary or permanent damage, such as skin blistering, and others, to disable people for a short time, either mentally or physically. A large enough dose of any of them, however, will kill. Chemical weapons can also be used to kill livestock and destroy crops. They can be sprayed from planes or dropped in bombs, or put into missiles, artillery shells, grenades and landmines.

Most chemical weapons are difficult and dangerous to make, store and handle. But a new type of weapon – the binary weapon – has solved this problem. The binary weapon uses two relatively safe chemicals that react and form a dangerous one, such as the nerve gas sarin (agent GB).

US Department of Defense/USAF

***Bigeye** is an aircraft-delivered binary chemical bomb developed by the USA. It contains two non-toxic chemicals, which come together on explosion to form a persistent nerve gas.*

Nerve gases are extremely potent chemicals that attack the body's nervous system, disrupting the nerve connections between the brain and the body. They act very quickly, and breathing in only a small amount will be fatal.

The two chemicals that make up the nerve gas are kept in separate compartments of the bomb, rocket warhead or shell – they only mix to form the deadly nerve gas when the weapon is launched.

Britain abandoned chemical weapons long ago, but some countries do have them, including the USA, Russia and France. However, recent statements by these countries indicate that they are willing to give up chemical weapons. The 1991 Gulf War demonstrated that they were of limited utility. A chemical weapons convention banning both the use and possession of such weapons has been signed by many, but not all, countries.

Biological warfare

Biological weapons are more strictly controlled than chemical ones. But with the coming of new techniques, such as the genetic engineering of viruses, the secret development of sinister new weapons is a possibility.

These could include battlefield weapons, which would make enemy soldiers ill and unable to fight, but would not kill them or cause long-term injury. A potent but short-lived flu virus, sprayed from the air a few days before an attack, or dysentery-causing amoebas put into the enemy's water supply by saboteurs, could incapacitate an entire population.

Biological weapons could also be used against civilians to disrupt the enemy's economy. If they could be delivered effectively, they could wipe out a country's population as effectively as nuclear weapons, but without the destruction and radioactive fallout. The enemy could then take over the country intact, sending in troops in protective clothing to deal with any survivors.

Crop attack

On a longer term basis, chemical or biological warfare could destroy a country's food supply. It could be used openly during a conventional war, for example, by spraying crops with herbicide. Or it could be used as a form of economic warfare, by contaminating crops with plant diseases, such as wheat rust, or infecting cattle with foot-and-mouth disease over several years.

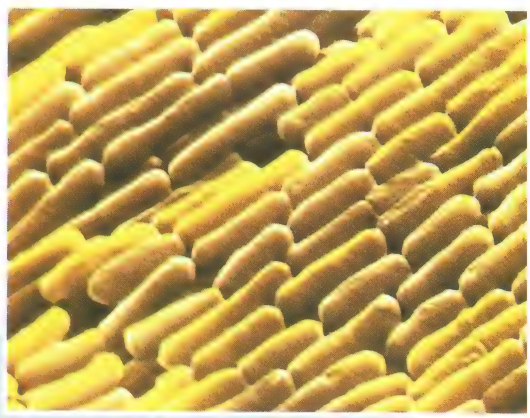
Weather control can also be used to cause drought or floods, though the technology barely exists at present. Clouds can be sprinkled with silver iodine crystals to trigger off rainfall, but the technique is only partly successful. By making clouds release rain before they reached a country's borders, it would be possible to reduce its rainfall at a crucial point in its crop-growing season.

However, new weather control techniques might be developed and could be used for hostile as well as peaceful purposes. This possibility is taken so seriously that an international treaty was signed in 1978 outlawing the military or hostile use of weather control and 'environmental modification techniques'.

FIGHTING DIRTY

Rex Features

The Iranians claim 5,000 of their men died when a single Iraqi plane dropped chemical bombs on them. Several others were wounded. Iraq has been accused consistently of using chemical weapons in spite of an international ban on them.



CNRI/SPL

***Secret research** on biological warfare, carried out by the Government in 1942, left the Scottish island of Gruinard ravaged by the anthrax virus (right). Anthrax results in pneumonia and pustulent sores, so the island was declared out of bounds for 46 years.*

TRH

Paul Raymonde

RADIATION DEVASTATION DEATH

IF THE BOMB FALLS...

Los Alamos National Laboratory/SPL Inset DOD/TRH

***Devastation** follows a nuclear blast. In August 1945, Hiroshima was reduced to a pile of rubble (inset). Many who survived the explosion died later of radiation.*

The world has lived in fear of nuclear war ever since the first atomic bomb fell on Hiroshima in 1945. If the fear of global warfare has receded since the end of the Cold War, the threat of nuclear attack remains as potent as ever.

The horrific estimates of millions of dead and injured which it is believed would follow a major nuclear strike are based on the aftermath of the only two atomic bombs ever used on human targets, those dropped on Hiroshima and Nagasaki to end World War II. The Hiroshima bomb killed 140,000 people when it exploded. Tens of thousands more died in later years from the delayed, but lethal, effects of radiation exposure.

These devastating results were caused by relatively primitive bombs with an explosive power of 12.5 kilotons, the same as that of 12,500 tons of TNT. Modern warheads are far more powerful with 750 kilotons being usual. The American Trident II D5 missile, now banned by international agreement, could carry up to 15 individual 335 kiloton warheads, a total of over 5 megatons (a megaton is a thousand kilotons).

Worst Scenario

The worst Cold War scenario involved international tension building up between the USA and the USSR. If one side felt sufficiently threatened, it might launch a pre-emptive strike. The aim would be to hit the enemy so hard with one attack that it could not strike back. But if the side under attack had enough time to launch all its missiles and bombers in retaliation, both sides would suffer appalling casualties.

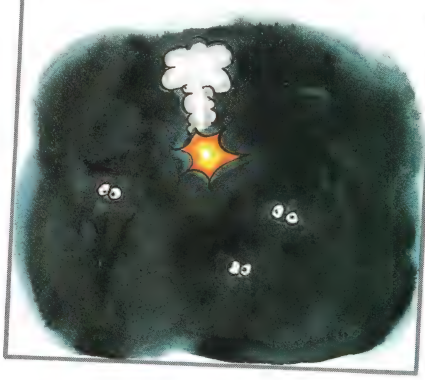
The survivors of the Hiroshima and Nagasaki bombs were fortunate that they lived in a country otherwise untouched by nuclear weapons. Food, shelter and medical care was provided from elsewhere in Japan. The survivors of an all-out nuclear war would not be so lucky. In such a war between the superpowers, Britain could have been attacked with a total of 300 megatons of nuclear weapons. An attack of this size could destroy or damage about two-thirds of all the buildings, kill or injure many millions of people and cause fires over about a quarter of the country. On top of all that, the whole country would be contaminated by dangerous levels of radioactivity.

With the emergency services effectively destroyed, medical and food aid would not exist and the wounded would have simply died. Food stores might have been so contaminated by radiation as to be poisonous, causing widespread starvation among the survivors.

Just amazing!

LIGHTS OUT!

THE ELECTROMAGNETIC PULSE FROM A 1-MEGATON TEST EXPLOSION 400 KM ABOVE A PACIFIC ISLAND FUSED ALL THE LIGHTS IN HAWAII, 1,300 KM AWAY.



Paul Raymonde

Nuclear Winter

The vast quantities of dust and smoke caused by widespread nuclear explosions in the warring nations would have risen into the upper atmosphere, blocking out the sunlight. If enough weapons were detonated this huge cloud would have drifted around the globe within two weeks, bringing darkness, winter and radioactive fallout to the world.

Temperatures would have dropped by about 20°C, and all the normal weather patterns would have been changed, bringing drought to some areas and floods to others. Plants not already killed by explosion, radiation, fire, cold, drought or flood would not have got enough light to grow, and crops would have failed all round the world. Cold, sick, scared and hungry, the human race would have faced extinction.

Gamma/Frank Spooner Pictures

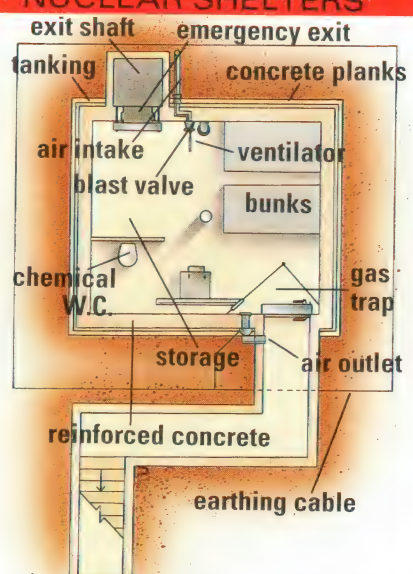
Bundesamt für Zivilschutz

Designer nuclear *shelters may be popular for the well-heeled in the USA. But the Swiss who want to provide protection for everyone, have opted for the more utilitarian version (left).*

Protective clothing *is vital to deal with nuclear fallout.*

Gamma/Frank Spooner Pictures

NUCLEAR SHELTERS



In order to withstand the blast, a nuclear shelter needs to be made of steel or be a reinforced concrete construction. Any dense material such as earth, brick or concrete slows the passage of the gamma rays and neutrons which the fallout emits.

Mark Franklin

Since the collapse of Communism in Central Europe and the continuing disintegration of the former Soviet Union, such a catastrophic worldwide nuclear war has become increasingly unlikely. However, to the surprise of some, nuclear war itself has become more likely.

Proliferation

Known as proliferation, the spread of nuclear weapons to other countries is the major threat facing the world today. Many governments have signed treaties promising not to acquire nuclear weapons, in return for other technological aid. However, there remain several potential flahspoints throughout the world.

One of the more potent of these is in southern Asia. India and Pakistan have long disputed the border region of Kashmir. The dispute has led to war in the past and bad feeling remains between the two nations. It is thought that both India and Pakistan are developing the technology needed to create weapons-grade uranium. Any future war over Kashmir might turn nuclear, devastating the region. However, the same deterrent effect which stopped America and the Soviet Union from launching their weapons may inhibit India and Pakistan from using theirs.

More alarming is the possibility that unstable or aggressive governments may gain control of nuclear weapons. Iraqi scientists working on developing nuclear power stations have been diverted to creating nuclear weapons. President Saddam Hussein is thought to be unpredictable enough to use such a weapon. He used banned chemical weapons during his war with Iran in the 1980s. United Nations monitors tried to dismantle Iraqi nuclear technology following the Gulf War of 1991, but it is unclear how far they succeeded.

President Gaddafi of Libya is another dictator with the potential for developing atomic weapons. Libya's links to various terrorist groups around the world make this a particularly worrying development.

South Africa is also thought to be close to gaining primitive atomic weapons, if it has not already done so. The continuing political uncertainty in that nation is destabilising the region and makes it unclear who will eventually gain control of the military, together with any nuclear technology.

Even more alarming is the fact that may Soviet nuclear weapons were based in areas of the Soviet Union now breaking away from Russia. Some regimes which have gained control are notoriously unstable and dictatorial. One republic is reported to have been taken over by a criminal gang. It is a worrying possibility that such governments may sell missiles and bombs to Third World nations for much needed cash.

Proliferation threatens to put nuclear weapons into the hands of those more likely to use them than were the super powers during the Cold War.

SCi-Fi FOODS

Terence Moore/Susan Griggs

MAN HAS ALWAYS DREAMED of making deserts bloom, and growing foods where there were only barren sands. As traditional farmlands become increasingly overworked, the agricultural future may lie in reclaiming the deserts.

A project on the arid La Mancha plain of Spain combines a unique solar energy experiment with a new concept in 'greenhouse' cultivation. A towering 'solar chimney' is surrounded by a large area of the La Mancha plain roofed over with light-permeable plastic. Heat collecting under this massive greenhouse panel rushes up the chimney at night as the outside air cools, driving turbines that generate electricity. Crops grown under the huge canopy benefit from a hot, moist atmosphere during the day, and during cold seasons and periods of cold weather, heat levels in the growing area can be boosted from the stored electricity generated by the solar chimney.

Synthesized foods

Many scientists see the future of bulk food supplies being secured by an entirely new range of synthesized foods. It is now perfectly possible to reproduce the enzyme processes by which a cow converts grass into milk in the laboratory. A mechanically chewed 'cud' of vegetable matter can be filtered down through a succession of layers of fixed-bed enzymes – synthetic copies of the enzymes formed in the cow's body by its metabolism. The vegetable matter goes through the same sequence of changes that occur naturally in the dairy cow, emerging at the end of the process as milk.

***A nutrient mist** provides food and water for the spinach being cultivated on the walls of this plastic drum. The drum revolves slowly so that all the plants receive the same amounts of light and gravity.*

Leaf protein

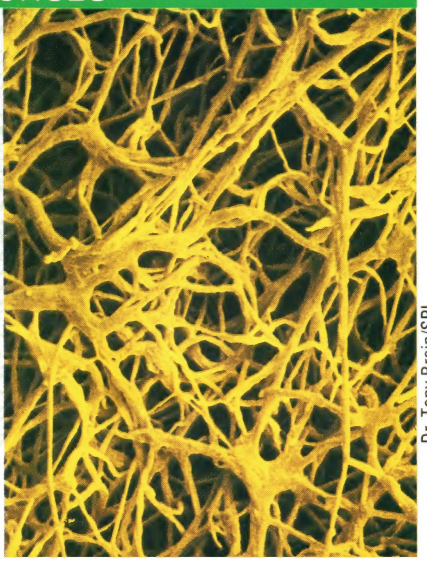
Natural fodder can also be used to produce proteins by a different method, breaking them down mechanically so that cell-walls and membranes are ruptured, releasing the cytoplasm that contains the plant's proteins. The protein-rich leaf-juice can then be transformed into the required form by further refining, ending up as a powder, if required, which can be added to other foods.

This leaf protein concentrate (LPC) can be extracted from a huge variety of sources, perhaps even the wild grass and forest-lands of the world. These are potential protein-factories, many times more efficient than the animals used to convert grass into meat.

Another great advantage of the LPC processes is that they can be applied to vegetable matter currently wasted during normal cropping of vegetables such as peas, beans, and root-crops, where the leafy vegetation is discarded. It has been estimated that as much as half the

MAXIMIZING PROTEIN SOURCES

Myco-protein, sometimes described as a distant relative of the mushroom, is produced by fungi. These plants are also the source of many useful and unusual drugs. The protein, which is tasteless, can be artificially flavoured to taste like any meat or poultry; it is low-fat and has the same amount of dietary fibre as fresh green vegetables. The long growing threads called mycelia (seen here through an electron microscope) are woven into a basic fibre which is transformed into meat analogues – items that closely resemble familiar foods such as chicken or beef. This is now on sale in many supermarkets.



Dr. Tony Brain/SPL

Just amazing!

FUELLING UP

SCIENTISTS BELIEVE THAT ONE DAY PETROL COULD FILL OUR STOMACHS AS WELL AS OUR CARS. A BACTERIA WHICH GROWS ON PETROLEUM IS NOW BEING INVESTIGATED AS A POSSIBLE SOURCE OF PROTEIN.

Paul Raymonde

protein in a crop is wasted in this manner. The main problem with LPC is in getting people to try something new. In most people's minds 'greenburgers' belong to science fiction.

Utilizing bacteria

Yeast and bacteria can be cultivated and have been used commercially to produce animal feeds. One advantage of feeding yeast and bacteria proteins to livestock is that the huge amounts of fish, soya and oil-seed, which produce expensive animal proteins, would then be free for human consumption.

Replicating resistance

The resistance of plants to disease is often conferred by a single gene, which scientists hope to transfer from plants bearing it, to those that are without it. Some genetic improvements are achieved by transferring resistances in one variety to other varieties of the same plant. Successful gene splitting and implantation might well produce insect-free commercially grown vegetables in the future.

Cell fusion

Related species, such as the tomato and the potato, have been subjected to cell-fusion to produce hybrids known as pomatoes or topatoes. First examples produced neither good tomatoes nor good potatoes, but when the techniques have been refined, a single plant will produce food above and below ground at the same time. Further fusions might be possible between crop plants and succulents, such as pineapples and cacti, which use a tenth of the water employed by other plants to produce an equivalent amount of dry weight. If succulent metabolism, which enables these plants to keep leaf pores closed during the day, could be transferred to wheat, for example, the wheat-growing areas of the world could be enlarged by 300–400 per cent.

The breakthrough most plant scientists are eager to see is the introduction into conventional crops of the ability to fix nitrogen. Only certain leguminous plants can do this naturally. This will enable high-yielding crops to be grown without nitrogen fertilizers.

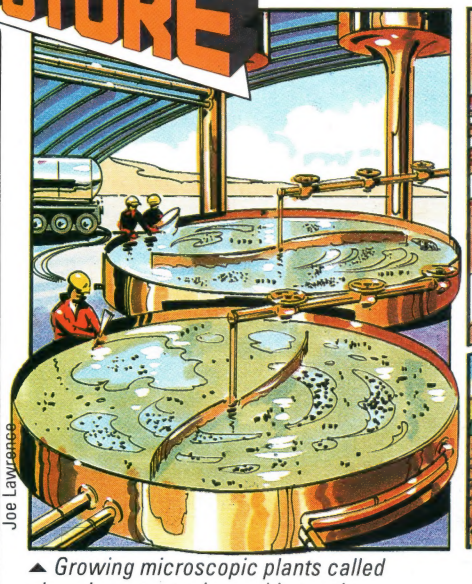
CLONING PLANTS FOR MAXIMUM YIELD

Research scientists are now using tissue culture techniques to grow clones of a parent plant in an attempt to increase the yield of various crops. One of the first examples of successful cloning involved the oil palm. Samples of root were taken from a high yielding oil palm and placed in a special nutrient solution. The cells of the root began to multiply and formed a mass known as a callus (right). From this callus, tiny oil palm plants began to grow. These were transferred to individual test tubes and kept in a controlled environment; the fledgling plants were fed the various nutrients required at different stages of their growth. The young plants were removed from the test tubes, but kept indoors until they were firmly established, then they were transferred to special growing bags outdoors until ready for planting in the fields.

Unilever

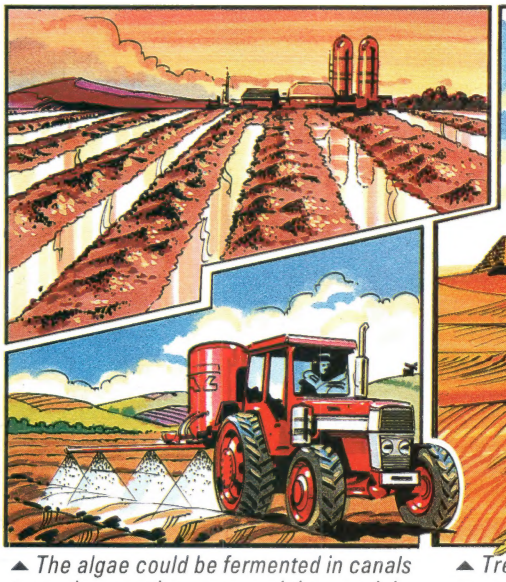
INTO THE FUTURE

BEATING THE DESERT

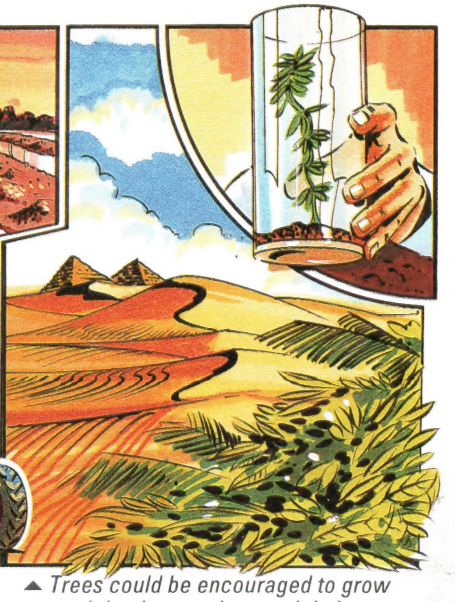


Joe Lawrence

▲ *Growing microscopic plants called algae in water tanks could stop the advance of the Sahara Desert and make its fringes fertile.*



▲ *The algae could be fermented in canals to produce methane gas and the remaining sludge used as fertilizer for farming projects.*



▲ *Trees could be encouraged to grow around the desert edges and their presence might eventually increase local rainfall levels.*

SUPERMARKET 2000

***Food supermarkets** sell thousands of items a week. Flat-bed scanners speed up check-out time for the store and shopper.*

Paul Shambroom/SPL

- BAR CODING
- FLAT-BED SCANNER
- INTEGRATED CHIPS

IT'S NOT ONLY SERGEANTS and corporals who wear stripes these days – canned and packaged food have got into the act as well now they are all marked with bar codes.

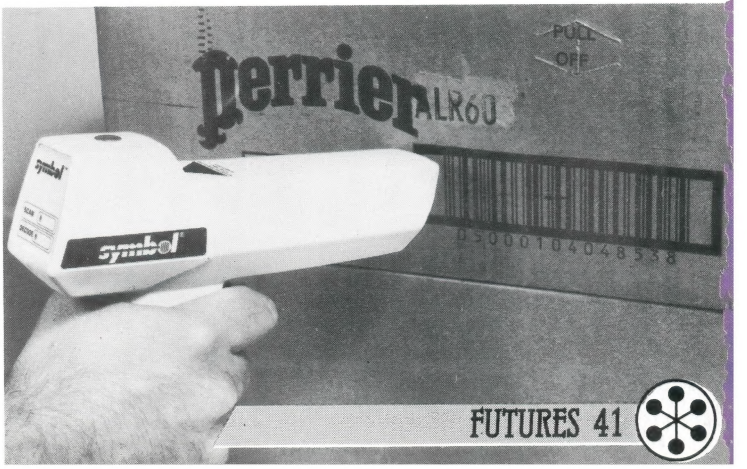
Bar codes are the vertical stripes printed on the back of nearly all packaged food items and form the basis of the systems that are used in most supermarkets. These patches of black stripes started to appear in the early 1980s and have now spread to 99 per cent of manufactured food items.

The bar code gives a unique identity to each different product and to each different size of the product. In food supermarkets, the code is read by a flat bed scanner sunk into the surface of the check-out. The items in the customer's basket or trolley are placed on the surface of the check-out, then passed over the scanner head one-by-one. The goods must all be aligned so that the bar code passes directly over the scanner.

Provided that the bar code has been drawn accurately in the first place and the stripes are the standard depth, the scanner can read the code at any angle and get it right nearly 100 per cent of the time. When the bar code passes over the scanner, the stripes are translated into eight or 13 figure numbers and are passed to a micro-computer built into the check-out till.

Ringing the changes

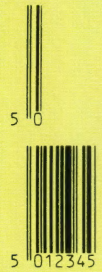
The price of each item of food can change many times in a year. In the past, each item on the shelves had to be relabelled every time. With the bar code system, the till computer uses the information from the bar code to look up the price in its



***A hand-held reader** translates the bar codes printed on the outside of many delivery cartons. The information is recorded inside the bar code reader, then transmitted to the central stock control computer at the close of business when phone costs are low.*

ANA UK Ltd

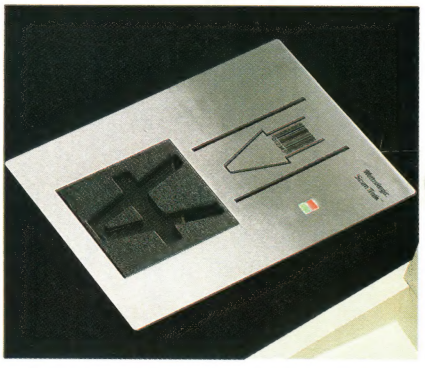
HOW A BAR CODE IS MADE UP



The first two numbers in a bar code indicate the country of issue. The next five identify the company selling the particular food item. The block of five numbers after that describes the product. The final number is a check that the code is correct using the sum and difference method.

There are a million million different combinations of bar code stripes so a bar code reader (right) must work very accurately. The latest readers achieve close to 100 per cent accuracy if the bar code is well printed.

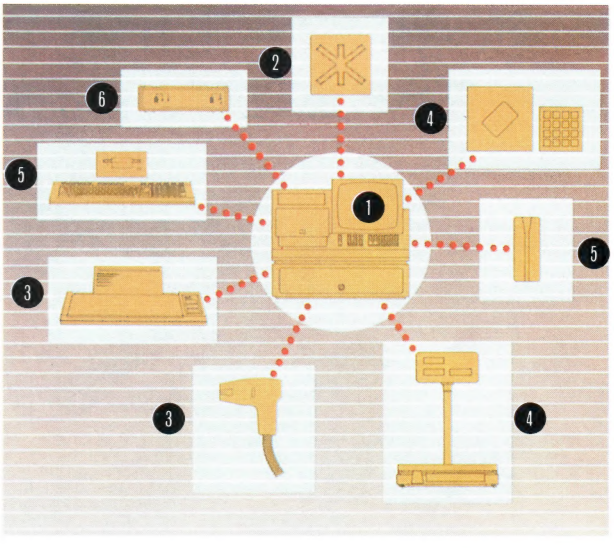
ANA UK Ltd.



memory. This is known as the Price Look Up (PLU) facility. The price is then flashed up on the till display and printed out on the till receipt. Prices can be changed by simply feeding fresh information into the till computer.

This can be done at the store level, but when the till computer is connected to a main-frame computer at the supermarket Head Office, one instruction to the main frame can change the price in every branch in the country.

In some American supermarkets, the price is announced through a speaker at the same time as it appears on the visual read-out. This helps the customer check the price is right.



***An Integrated Retailing System** has several peripherals connected to a micro-computer.*
***1** Sentinel till with micro-computer and Electronic Funds Transfer facilities*
***2** Flat-bed scanner*
***3** Micro-computer and bar-code reader for stock control*
***4** Weighing machines with facility to issue bar coded labels*
***5** EFTPOS terminal*
***6** Modern data link*

Stocking systems

Most stores using scanners have tills that are connected to a Head Office main-frame computer. This enables the main-frame to tick off the goods that are sold at the check-outs against the stocks recorded at Head Office. When a pre-determined stock level is reached, fresh supplies are ordered from the manufacturer just in time to prevent each particular branch from running out. This avoids food sitting around in supermarket warehouses.

Bar codes are also printed on the cardboard boxes that manufactured food is packed in. When the boxes are unloaded from the delivery lorry at the supermarket, these extra-long codes are read with a hand-held reader. This may be connected by wire to a mini-computer in the supermarket; alternatively, it records the data on tape so that it can be relayed to the Head Office main-frame later.

These bar codes do not just indicate the type of goods in the box, they also indicate the quantities as well. The recorded information is used to keep stock records up-to-date, without any need for paperwork. If a scanner check-out with a micro-computer in the till is connected to a Head Office main-frame and if delivery and stock information is fed into the Head Office as well, then one overall computer system is able to control all the activities of a whole supermarket chain.

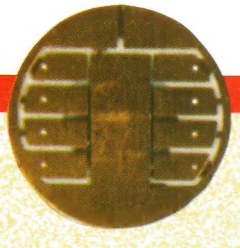
In an integrated retailing system, already in use in some countries, a fully electronic payment system works alongside the electronic till. Using the EFTPOS concept, the customer presents a plastic card at the check-out. This is inserted into a terminal which reads off various data and account details about the cardholder. If the information is acceptable to the computerised terminal, the EFTPOS will allow the sale to go ahead, the amount of the bill being deducted either from credit points stored on the card or from the cardholder's bank account.

Electronic sales

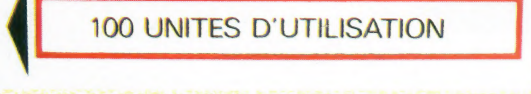
Sales information is stored in the memory until the EFTPOS terminal calls up the main-frame to run a check on a customer, or until after midnight when it is cheaper to send the data along telephone lines. When the information reaches the computer where the customer's account is held, the money is transferred to the supermarket's account.

In France three million smart cards are already in use. Each card contains a tiny silicon chip which acts as a microprocessor when fed into the EFTPOS terminal. In Britain, the EFTPOS concept uses the magnetised strip on plastic cards, a technology already used by credit cards and automatic bank cash withdrawal cards. The standard magnetised strip can contain two lines of information, though later versions may be able to hold far more information.

SMART MONEY



The Bull CP8 Smart Card has a memory chip with details of the user's credit worthiness – this is automatically checked at the till without delay. The bill is charged to the card holder's account on the same day.



Honeywell Bull